529 Rec'd PCT/PTO 08 MAY 2000

FORM PTO-1390 REV. 5-93	US DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEYS DOCKET NUMBER P00,0861
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		U.S.APPLICATION NO. (if known, see 37 CFR 1.5) 09/530983

INTERNATIONAL APPLICATION NO. PCT/DE98/03229	INTERNATIONAL FILING DATE 05 NOVEMBER 1998	PRIORITY DATE CLAIMED 07 NOVEMBER 1997

TITLE OF INVENTION
ARRANGEMENT FOR PREDICTING AN ABNORMALITY OF A SYSTEM AND FOR IMPLEMENTING AN ACTION OPPOSING THE ABNORMALITY

APPLICANT(S) FOR DO/EO/US
GUSTAVO DECO ET AL.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay.
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of International Application as filed (35 U.S.C. 371(c)(2)) - drawings attached.
   a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2) - drawings attached.
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. §371(c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☒ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98; **(PTO 1449, Prior Art, Search Report)**.
12. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 C.F.R. 3.28 and 3.31 is included. **(SEE ATTACHED ENVELOPE)**
13. ☒ Amendment "A" Prior to Action.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information:
    a. ☒ Submission of Informal Drawings - 2 sheets of drawings, Figures 1-3; and Request for Approval of Drawing Modifications, 2 sheets of drawings, Figures 1-3.
    b. ☒ EXPRESS MAIL # EL 544622679US dated May 8, 2000.

U.S. APPLICATION NO (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
09/530983	PCT/DE98/03229	P00,0861

17. ☒ The following fees are submitted:	CALCULATIONS	PTO USE ONLY
BASIC NATIONAL FEE (37 C.F.R. 1.492(a)(1)-(5): Search Report has been prepared by the EPO or JPO $840.00		
International preliminary examination fee paid to USPTO (37 C.F.R. 1.482) . . $670.00		
No international preliminary examination fee paid to USPTO (37 C.F.R. 1.482) but international search fee paid to USPTO (37 C.F.R. 1.445(a)(2) $760.00		
Neither international preliminary examination fee (37 C.F.R. 1.482) nor international search fee (37 C.F.R. 1.445(a)(2) paid to USPTO $970.00		
International preliminary examination fee paid to USPTO (37 C.F.R. 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) . . . . . $ 96.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 840.00	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 C.F.R. 1.492(e)).	$	

Claims	Number Filed		Number Extra	Rate	
Total Claims	17	- 20 =	0	X $ 18.00	$
Independent Claims	03	- 3 =	0	X $ 78.00	$
Multiple Dependent Claims				$260.00 +	$
			TOTAL OF ABOVE CALCULATIONS =		$ 840.00
Reduction by ½ for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 C.F.R. 1.9, 1.27, 1.28)					$
			SUBTOTAL =		$ 840.00
Processing fee of $130.00 for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				+	$
			TOTAL NATIONAL FEE =		$ 840.00
Fee for recording the enclosed assignment (37 C.F.R. 1.21(h). The assignment must be accompanied by an appropriate cover sheet (37 C.F.R. 3.28, 3.31). $40.00 per property				+	
			TOTAL FEES ENCLOSED =		$ 840.00
				Amount to be refunded	$
				charged	$

a. ☒ A check in the amount of $ 840.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of $ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 08-2290. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 C.F.R. 1.494 or 1.495 has not been met, a petition to revive (37 C.F.R. 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

Hill & Simpson
A Professional Corporation
85th Floor Sears Tower
Chicago, Illinois 60606

Steven H. Noll
SIGNATURE

Steven H. Noll
NAME

28,982
Registration Number

BOX PCT
IN THE UNITED STATES DESIGNATED/ELECTED OFFICE
OF THE UNITED STATES PATENT AND TRADEMARK OFFICE
UNDER THE PATENT COOPERATION TREATY--CHAPTER II

APPLICANT(S):	GUSTAVO DECO ET AL.
ATTORNEY DOCKET NO.:	P00,0861
INTERNATIONAL APPLICATION NO:	PCT/DE98/03229
INTERNATIONAL FILING DATE:	05 NOVEMBER 1998
INVENTION:	ARRANGEMENT FOR PREDICTING AN ABNORMALITY OF A SYSTEM AND FOR IMPLEMENTING AN ACTION OPPOSING THE ABNORMALITY

Assistant Commissioner for Patents,
Washington D.C. 20231

AMENDMENT "A" PRIOR TO ACTION

Sir:

Applicants herewith amend the above-referenced PCT application, and request entry of the Amendment prior to examination on the United States Examination Phase.

IN THE SPECIFICATION:

On page 1:

cancel lines 1-3 and substitute the following:

--SPECIFICATION

TITLE

ARRANGEMENT FOR PREDICTING AN ABNORMALITY OF A SYSTEM AND FOR IMPLEMENTING AN ACTION OPPOSING THE ABNORMALITY

BACKGROUND OF THE INVENTION

Field of the Invention-- therefor;

above line 6, insert

--Description of the Related Art--;

in lines 6-7, cancel "[1] and/or [2]" and substitute --G. Deco, C. Schittenkopf and B. Schürmann, "Determining the information flow of dynamical systems from continuous probability distributions", Phys. Rev. Lett. 78, pages 2345-2348, 1997 (Deco), and C. Schittenkopf and G. Deco, "Testing non-linear Markovian hypotheses in dynamical systems", Physica D104, pages 61-74, 1997 (Schittenkopf)-- therefor;

in line 8, after "flow", insert --described in these references-- therefor;

in line 11, cancel "the" and substitute --such an-- therefor, and cancel "comprised therein";

in line 12, cancel "this leading thereto that" and substitute --allowing-- therefor;

in line 13, cancel "is" and substitute --to be-- therefor;

in line 14, cancel "[3]" and substitute --J. Herz, A. Krogh, R. Palmer, "Introduction to the Theory of neural computation", Addison-Wesley, 1991 (Herz)-- therefor;

above line 15, insert --SUMMARY OF THE INVENTION--;

in line 15, cancel "comprised in specifying" and substitute --to provide-- therefor;

in lines 15-16, cancel ", first,", and before "implements", insert --then--;

cancel line 18, and substitute --This object is achieved by an arrangement for predicting an abnormality of a dynamic system and for implementing an action opposing the abnormality, comprising:

a) a measured data pick-up that registers comparison measured data of the system and test measured data of the system;

b) a processor unit, having a neural network that models the system, the processor:

(1) training the neural network using the comparison measured data;

(2) determining a comparison information flow that describes a comparison dynamic of the system using the trained neural network;

(3) determining a test information flow that describes a test dynamic of the system using the test measured data;

(4) using the comparison information flow and of the test information flow, predicting the abnormality as established when the comparison information flow differs significantly from the test information flow and predicting the abnormality as not established when the comparison information flow does not significantly differ from the test information flow;

(5) when the abnormality of the system has been predicted as established, then implementing the action; and

c) an actuator that implements the action.

This object is also achieved by a method for predicting an abnormality of a dynamic system and for implementing an action opposing the abnormality, comprising the steps of:

a) measuring comparison measured data of the system and test measured data of the system;

b) determining a neural network that models the system using of the comparison measured data;

c) determining a comparison information flow that describes a comparison dynamic of the system using the neural network;

d) determining a test information flow that describes a test dynamic of the system using the test measured data;

e) comparing the comparison information flow to the test information flow using the comparison information flow and of the test information flow;

f) determining the abnormality to be predicted as established when the comparison information flow differs significantly from the test information flow;

g) determining the abnormality to be predicted as not established when the comparison information flow does not significantly differ from the test information flow; and

h) implementing the action when the abnormality of the system has been predicted as established.

Finally, this object is achieved by a method for predicting an abnormality of a dynamic system, comprising the steps of:

a) measuring comparison measured data of the system and test measured data of the system;

b) determining a comparison information flow that describes a comparison dynamic of the system using the comparison measured data;

c) determining a test information flow that describes a test dynamic of the system] using the test measured data;

d) comparing the comparison information flow to the test information flow using the comparison information flow and of the test information flow;

e) determining the abnormality to be predicted as established when the comparison information flow differs significantly from the test information flow;

f) determining the abnormality to be predicted as not established when the comparison information flow does not significantly differ from the test information flow.-- therefor;

in line 20, cancel ". A" and substitute -- that has a-- therefor;

in line 21, cancel "is provided therein";

in line 22, cancel "unit is configured such that" and substitute --implements-- therefor, and cancel "are implemented";

in line 24, cancel "employed in order" and substitute --used-- therefor;

in line 27, cancel ";" and substitute --.-- therefor; and

in line 28, cancel "an" and substitute --An-- therefor, and cancel "thereby provided dependent" and substitute --provided in the arrangement that depends-- therefor;

On page 2:

in line 1, before "systematic", insert --to provide--, and cancel "and" and substitute --,-- therefor;

cancel line 2 and substitute --to derive a solution of this general problem from it and to determine a quantity-- therefor;

in line 3, after "quantity", insert --)--;

in line 4, cancel "attack on" and substitute --abnormality in-- therefor;

in line 10, cancel "adequately general in order" and substitute --be general enough-- therefor;

in line 19, cancel "It is thereby to be taken into consideration" and substitute --One also considers-- therefor;

in line 21, cancel ", this being" and substitute --; this is-- therefor, and after "i.e.", insert --,--;

in line 22, cancel ",";

in line 23, cancel "is comprised therein that the" and substitute endlessly loops through-- therefor;

in line 24, cancel "form an endless loop";

in line 25, cancel "comprised therein that" and substitute --deals with the situation where-- therefor;

in line 26, after "dynamic", insert --value--;

in line 27, cancel "comprised in" and substitute --comprised of-- therefor;

in line 28, cancel "the noise" and substitute --this noise-- therefor; and

in line 30, cancel "thereby" and cancel "on the basis of" and substitute --using-- therefor.

On page 3:

in line 1, cancel "is comprised therein that" and substitute --deals with a situation where-- therefor;

in line 2, after "dynamic", insert --value--;

cancel line 3 and substitute --The system may be excited, in reaction, with a regular signal. This can-- therefor;

in line 4, cancel "ensue" and substitute --take place-- therefor;

in line 5, cancel "on the basis of" and substitute --using-- therefor;

cancel line 9 and substitute --Developments of the invention are discussed below.--

above line 10, insert --BRIEF DESCRIPTION OF THE DRAWINGS --;

cancel line 12;

in line 13, after "Figure 1", insert --is a block diagram showing--;

in line 15, after "Figure 2", insert --is a block diagram showing--, and cancel "al" and substitute --, an-- therefor;

in line 17, before "steps", insert --is a flowchart showing-- and cancel "the";

above line 18, insert --DESCRIPTION OF THE PREFERRED EMBODIMENTS--; and

in line 23, cancel "and processed thereat" and substitute --where they are processed--.

On page 4:

in line 1, cancel "Let it thereby be noted that the" and substitute --The-- therefor;

in lines 7-8, cancel "Via the interface 201, this" and substitute --This-- therefor;

in line 8, after "PRE", insert --, via the interface 201,--;

in line 10, cancel "Further" and substitute --Furthermore-- therefor, and cancel "AKT2," and substitute --AKT2.-- therefor;

in line 11, cancel "this" and substitute --This-- therefor, and cancel "applying" and substitute --applies-- therefor;

in line 12, cancel "thereby";

cancel lines 17-25 and substitute

-- A neural network NN is trained as follows. Both comparison data and test data are measured using the measured data pick-up MDA in process 302. The neural network NN is modeled based on the comparison measured data in process 304. This modeling is used to demarcate normal operation from abnormal operation, and permits a later determination of whether newly measured data indicates an abnormality in the system. After the end of the training, information flows according to Deco or Schittenkopf are evaluated. A comparison information flow describing a comparison dynamic of the system is determined using the trained neural network NN in process 306. A test information flow describing a test dynamic of the system is determined using the test measured data in process 308. A comparison as to whether the test information flow differs significantly, according to some predetermined criteria, from the comparison information flow is performed in decision 310. If the comparison difference is significant, this is indicative of an abnormality that is predicted--such an abnormality of the system can be indicated on the basis of this information flow before the occurrence of this abnormality. When a predicted abnormality is established, an action that opposes an occurrence of the abnormality is implemented in process 312, and a branch is made preferably to process 306. If the comparison difference is not significant,

then the predicted abnormality is not established, and no action is implemented; a branch is made preferably to process 306.-- therefor;

in line 26, cancel "these illustrating" and substitute --that illustrate-- therefor.

On page 5:

in line 3, cancel "is comprised therein that" and substitute --occurs when-- therefor;

in line 5, before "training", insert --the--, and cancel "It should";

in line 6, cancel "thereby be noted that the" and substitute --The-- therefor;

in line 7, cancel "at the" and substitute --at a particular-- therefor;

in line 9, cancel "the person" and substitute --a person,--, cancel "should" and substitute --, are--, and cancel "be";

in line 17, cancel ", preferably the human brain," and substitute --(e.g., a human brain)-- therefor;

in line 19, cancel "thereto. Thus, an" and substitute --to them. An-- therefor;

in line 22, cancel "thereto" and substitute --to this-- therefor;

in line 23, after "i.e.", insert --,--;

in line 30, cancel "We shall turn to the" and substitute --The-- therefor; and

cancel line 31 and substitute --attack is presented below for more in-depth discussion-- therefor.

On page 6:

in line 3, cancel "[2]" and substitute --Schittenkopf-- therefor;

in line 4, cancel "form" and substitute --from-- therefor;

in line 5, cancel "surround of the" and substitute --area of-- therefor;

in line 11, cancel "whereby" and substitute --where-- therefor;

in line 12, cancel "..." and substitute --x_{t-1},..., x_{t-n}-- therefor;

in line 16, cancel "[4]" and substitute --G. Deco, D. Obradovic, "An Information-Theoretic Approach to Neural Computing", Springer-Verlag, 1996, Chapter 7.2 (Obradovic)-- therefor;

in line 18, cancel "whereby" and substitute --where-- therefor, and cancel "[sic]";

in line 23, cancel "thereto" and substitute --to it-- therefor; and

in line 27, cancel "[2]" and substitute --Schittenkopf-- therefor.

On page 7:

in line 1, cancel "[1] and[2]" and substitute --Deco and Schittenkopf-- therefor, and after "i.e.", insert --,--;

in line 3, cancel "thus", and cancel "whereby" and substitute --where-- therefor;

in line 4, after "i.e.", insert --,--;

in line 9, cancel "thereby to test" and substitute --to test, in this analysis,-- therefor;

in line 12, after "i.e.", insert --,--;

in line 22, cancel "[5]" and substitute --B. Gluckmann, E. Neel, T. Netoff, W. Ditto, M. Spano, S. Schiff, "Electric field suppression of epiletiform activity in hippocampal slices", Journal of Neurophysiology 76, pages 4202-4205, 1996 (Gluckmann)-- therefor;

in line 26, after "i.e.", insert --,--; and

in line 27, cancel ", the brain in this case" and substitute --(the brain, in this case)-- therefor.

On page 8:

in line 7, after "brain,", insert --and--;

in line 8, cancel "thus";

in line 9, cancel ", whereby" and substitute --by the inventive system in which-- therefor;

in line 10, cancel "Dependent of" and substitute --Depending on-- therefor;

in line 11, cancel "is comprised" and substitute --may be-- therefor, cancel the first "in" and after "chaotic", insert --field--;

in line 14, cancel "whereby" and substitute --in which-- therefor;

in line 16, cancel "It is thereby expedient to" and substitute --The methods then" therefor";

in line 18, before"of the", insert --e.g.,--;

in line 19, cancel "this" and substitute --the abnormality-- therefor;

in line 23, cancel "expedient" and substitute --necessary-- therefor;

in line 26, after "example", insert --,--;

in line 27, cancel "the greatest" and substitute --a great-- therefor, and cancel "whereby" and substitute --and where-- therefor; and

below line 28, insert

-- The above-described method is illustrative of the principles of the present invention. Numerous modifications and adaptions thereof will be readily apparent to those skilled in this art without departing from the spirit and scope of the present invention.--.

Delete page 9.

IN THE CLAIMS:

On substitute page 10:

line 1, replace "**Patent Claims**" with --WHAT IS CLAIMED IS:--.

Please amend claims 1-17 as follows:

1. (Amended) An arrangement [Arrangement] for predicting an abnormality of a dynamic system and for implementing an action opposing the abnormality, comprising:

a) [whereby] a measured data pick-up [is provided] that registers comparison measured data of said [the] system and test measured data of said [the] system; [,]

b) [comprising] a processor unit, having a neural network that models said system, said processor unit [that is configured such that the following steps can be implemented:]

[c)] (1) training said [a] neural network [that describes the system is trained upon employment of] using said [the] comparison measured data;

(2) determining a comparison information flow that describes a comparison dynamic of said [the] system [is determined upon employment of] using said [the] trained neural network;

(3) determining a test information flow that describes a test dynamic of said [the] system [is determined upon employment of] using said [the] test measured data;

(4) [upon employment of] using said [the] comparison information flow and [of] said [the] test information flow, predicting said [the] abnormality [is predicted] as established when said [the] comparison information flow differs significantly from said [the] test information flow and predicting said [the] abnormality [is predicted] as not established when said [the] comparison information flow does not significantly differ from said [the] test information flow;

(5) when said [the] abnormality of the system has been predicted as established, then implementing said [the] action [is implemented]; and

c) [whereby] an actuator that implements said [the] action [is provided].

2. (Amended) An arrangement [Arrangement] according to claim 1, wherein said [whereby the steps (2) and (5) of the] processor unit endlessly loops from said step of determining a comparison information flow to said step of implementing said action [form an endless loop].

3. (Amended) An arrangement [Arrangement] according to claim 1 [or 2], wherein said [whereby the] abnormality is predicted as established when said test information flow is significantly smaller than said [the] comparison information flow.

4. (Amended) An arrangement [Arrangement] according to claim 3, wherein said [whereby the] action comprises [is comprised in] exciting said [the] system with a chaotic signal.

5. (Amended) An arrangement [Arrangement] according to claim 4, wherein said [whereby the] action comprises supplying [is comprised in suppling] noise to said [the] system.

6. (Amended) An arrangement [Arrangement] according to claim 5, wherein said [whereby the] noise is supplied by [on the basis of] a corresponding electrical field.

7. (Amended) An arrangement [Arrangement] according to claim 6, wherein said [whereby the] electrical field is supplied by [on the basis of] at least one electrode.

8. (Amended) An arrangement [Arrangement] according claim 5, wherein said [whereby the] noise is supplied by [on the basis of] a corresponding magnetic field.

9. (Amended) An arrangement [Arrangement] according to claim 8, wherein said [whereby the] magnetic field is supplied by [on the basis of] at least one electrode.

10. (Amended) An arrangement [Arrangement] according to claim 1 [or 2], wherein said [whereby the] abnormality is predicted as established when said test information flow is significantly greater than said [the] comparison information flow.

11. (Amended) An arrangement [Arrangement] according to claim 10, wherein said [whereby the] action comprises [is comprised in] exciting said [the] system with a regular signal.

12. (Amended) An arrangement [Arrangement] according to claim 11, wherein said [whereby the] regular signal is supplied by [on the basis of] an electrical field.

13. (Amended) An arrangement [Arrangement] according to claim 11, wherein said [whereby the] electrical field is supplied by [on the basis of] at least one electrode.

14. (Amended) An arrangement [Arrangement] according to claim 11, wherein said [whereby the] regular signal is supplied by [on the basis of] a magnetic field.

15. (Amended) An arrangement [Arrangement] according to claim 14, wherein said [whereby the] magnetic field is supplied to said [the] system by [on the basis of] at least one electrode.

16. (Amended) A method [Method] for predicting an abnormality of a dynamic system and for implementing an action opposing the abnormality, [whereby] comprising the steps of:

a) measuring comparison measured data of said [the] system and test measured data of said [the] system; [are measured,]

b) determining a neural network that models said [describes the] system [is determined upon employment of] using said [the] comparison measured data;

c) determining a comparison information flow that describes a comparison dynamic of said [the] system [is determined upon employment of] using said [the] neural network;

d) determining a test information flow that describes a test dynamic of said [the] system [is determined upon employment of] using said [the] test measured data;

e) comparing said comparison information flow to said test information flow [e) upon employment of] using said [the] comparison information flow and of said [the] test information flow; [,]

f) determining said [the] abnormality to be [is] predicted as established when said [the] comparison information flow differs significantly from said [the] test information flow; [and]

g) determining said [the] abnormality to be [is] predicted as not established when said [the] comparison information flow does

not significantly differ from said [the] test information flow; and

h) [f)] implementing said action when said [the] abnormality of said [the] system has been predicted as established[, then the action is implemented].

17. (Amended) A method [Method] for predicting an abnormality of a dynamic system, comprising the steps of: [whereby]

a) measuring comparison measured data of said [the] system and test measured data of said [the] system; [are measured,]

b) determining a comparison information flow that describes a comparison dynamic of said [the] system [is determined upon employment of] using said [the] comparison measured data;

c) [d)] determining a test information flow that describes a test dynamic of said [the] system [is determined upon employment of] using said [the] test measured data;

d) comparing said comparison information flow to said test information flow [e) upon employment of] using said [the] comparison information flow and of said [the] test information flow; [,]

e) determining said [the] abnormality to be [is] predicted as established when said [the] comparison information flow differs significantly from said [the] test information flow; [and]

f) determining said [the] abnormality to be [is] predicted as not established when said [the] comparison information flow does not significantly differ from said [the] test information flow.

IN THE ABSTRACT

On page 12:

cancel lines 2-3;

in line 4, cancel "is" and substitute --and method are-- therefor, and cancel "enables" and substitute --enable-- therefor;

in line 5, cancel "implements" and substitute --implement-- therefor;

in line 6, cancel "thereby"; and

in line 8, cancel "therefrom" and substitute --from it-- therefor.

REMARKS

The present Amendment revises the specification and claims to conform to United States patent practice, before examination of the present PCT application in the United States National Examination Phase. All of the changes are editorial and applicant believes no new matter is added thereby. The amendment of claims 1-17 is not intended to be a surrender of any of the subject matter of those claims.

Early examination on the merits is respectfully requested.

Submitted by,

Steven H. Noll (Reg. No. 28,982)

Steven H. Noll
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A Professional Corporation
85th Floor - Sears Tower
Chicago, Illinois 60606
(312) 876-0200
Attorney for Applicant(s)

BOX PCT
IN THE UNITED STATES DESIGNATED/ELECTED OFFICE
OF THE UNITED STATES PATENT AND TRADEMARK OFFICE
UNDER THE PATENT COOPERATION TREATY--CHAPTER II

APPLICANT(S):	GUSTAVO DECO ET AL.
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Assistant Commissioner for Patents,
Washington D.C. 20231

REQUEST FOR APPROVAL OF DRAWING MODIFICATIONS

Sir:

Enclosed are copies of the drawings (Figures 1-3) showing in red, the addition of labels to Figures 1 & 2. The original Figure 3 has been cancelled and replaced. Applicants believe that no new matter has been added with this modification to Figure 3. Approval of the additions is respectfully requested.

Submitted by,

Steven H. Noll (Reg. No. 28,982)

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FIG 1

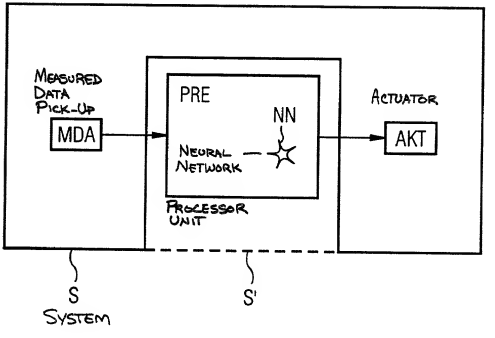

MEASURED DATA PICK-UP
MDA
PRE
NN
NEURAL NETWORK
PROCESSOR UNIT
ACTUATOR
AKT
S
SYSTEM
S'

FIG 2

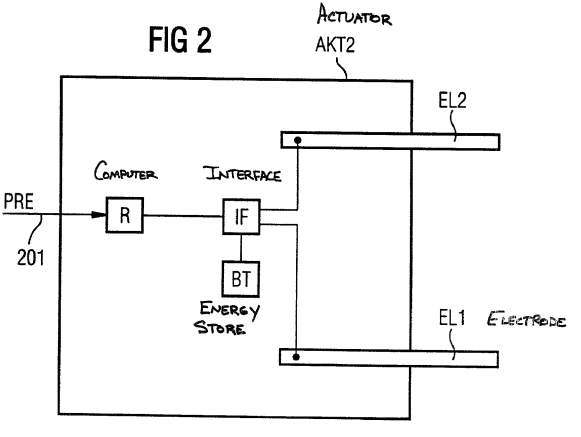
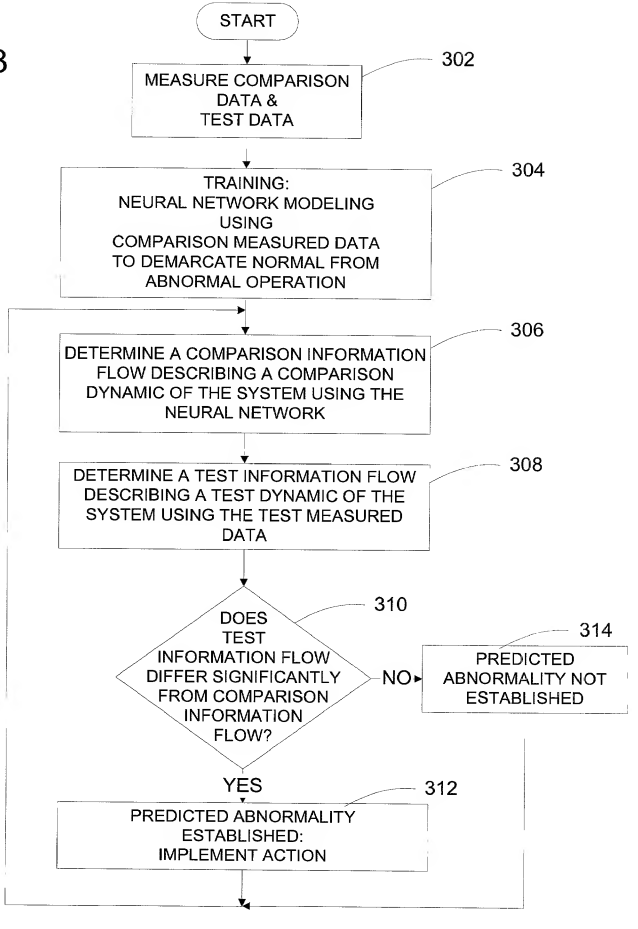

ACTUATOR
AKT2
EL2
COMPUTER
INTERFACE
PRE
R
IF
201
BT
ENERGY STORE
EL1
ELECTRODE

FIG 3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IN THE UNITED STATES DESIGNATED/ELECTED OFFICE
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UNDER THE PATENT COOPERATION TREATY--CHAPTER II

APPLICANT(S):	GUSTAVO DECO ET AL.
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INVENTION:	ARRANGEMENT FOR PREDICTING AN ABNORMALITY OF A SYSTEM AND FOR IMPLEMENTING AN ACTION OPPOSING THE ABNORMALITY

Assistant Commissioner for Patents,
Washington D.C. 20231

SUBMISSION OF INFORMAL DRAWINGS

Sir:

Applicant herewith submits 2 sheets (Figures 1-3) of informal drawings for the above-referenced PCT application.

Submitted by,

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ARRANGEMENT FOR PREDICTING AN ABNORMALITY OF A SYSTEM AND FOR IMPLEMENTING AN ACTION OPPOSING THE ABNORMALITY

The invention is directed to an arrangement for predicting an abnormality of a system and for the implementation of an action opposing the abnormality.

The determination of an information flow of a system is known from [1] and/or [2].

The information flow characterizes a loss of information in a dynamic system and describes decaying statistical dependencies between the entire past and a point in time that lies p steps in the future as a function of p. Among other things, the utility of the information flow is comprised therein that a dynamic behavior of a complex system can be classified, this leading thereto that a suitable parameterized model is found that enables a modelling of data of the complex dynamic system.

A neural network and the training of a neural network are known from [3].

The object of the invention is comprised in specifying an arrangement that, first, enables a prediction of an abnormality of a system and implements an action opposing the abnormality.

This object is achieved according to the features of patent claim 1.

An arrangement for predicting an abnormality of a system and for implementing an action opposing the abnormality is inventively recited. A measured data pick-up is provided therein that determines measured data of the system. A processor unit is configured such that the following steps are implemented:

(1) a neural network is trained on the basis of the measured data;

(2) the information flow of the system is employed in order to make a prediction about anticipated measured data;

(3) when the prediction indicates that the abnormality of the system is anticipated, the action is implemented;

an actuator that implements the action is thereby provided dependent on the respective application.

A goal of the invention is a systematic approach to the general problem and a solution of this general problem derived therefrom, the determination of a quantity (referred to below as prediction quantity that is suitable for predicting dynamic events of a system. The early recognition of a pattern that represents an attack on a "normal" behavior of the system is of great significance, as, among other things, the following applied examples document.

The applied strategy is divided into *three* steps:

1. The dynamically characterizing features of the system are extracted and adaptively learned (trained). The measure for learning the dynamics of the system in this dynamic learning phase should adequately general in order to correspond to stationary as well as non-stationary conditions. The dynamic learning phase is also used in order to demarcate a normal condition of the system from an abnormal condition (abnormality).
2. At least one variable (prediction quantity) is determined with which the abnormality is successfully described.
3. As soon as an occurrence of the abnormality is indicated, the information of the impending abnormality is used in order to oppose the impending abnormality via an actuator whose job is to restore the dynamic system into the normal condition. It is thereby to be taken into consideration that the normal condition is subject to a natural modification over the course of time, this being taken into consideration by adaption, i.e. continued training of the neural network, even after the learning phase.

One development is comprised therein that the steps (2) and (3) of the processor unit form an endless loop.

Another development of the invention is comprised therein that the predetermined abnormality is an information flow with a dynamic below a prescribable threshold. In this case, the action can be comprised in supplying the system with noise. It is possible to deliver the noise on the basis of a corresponding electrical field or a corresponding magnetic field. Both the electrical field as well as the magnetic field can thereby be supplied to the system on the basis of at least one electrode.

An additional improvement is comprised therein that the predetermined abnormality is an information flow having a dynamic above a predetermined threshold. Reaction thereto can be such that the system is excited with a regular signal. This can ensue on the basis of an electrical or magnetic field. The electrical field and/or the magnetic field can be respectively supplied to the system on the basis of at least one electrode.

In the framework of another development, it is also possible to utilize an electrical and a magnetic field in combination in order to oppose the abnormality.

Developments of the invention also derive from the dependent claims.

Exemplary embodiments of the invention are presented in greater detail on the basis of the following Figures.

Shown are:

Figure 1 an arrangement for predicting an abnormality of a system and for implementing an action opposing the abnormality;

Figure 2 an actuator AKT2 al active component, composed of a computer R, an interface IF, an energy store BT and two electrodes EL1 and EL2;

Figure 3 steps of a method for the implementation on a processor unit.

Figure 1 shows an arrangement for predicting an abnormality of a system and for implementing an action opposing the abnormality.

The measured data pick-up MDA registers measured data of a system S. To this end, the measured data pick-up MDA is preferably arranged within the system S in order to register the measured data on site. The measured data are conducted to a processor unit PRE and processed thereat. The processor unit PRE preferably comprises a neural network NN that, following training, suitably interprets further measured data registered by the measured data pick-up MDA. When there are indications that an action is to be implemented due to the measured data, an actuator AKT is initiated by the processor unit PRE to implement a predetermined action. The actuator preferably comprises at least one electrode that is directly driven by the processor unit PRE.

Let it thereby be noted that the processor unit is arranged in the system S', as indicated in Figure 1 on the basis of the broken line and the appertaining designation of the system S'.

The system S preferably comprises the measured data pick-up MDA and/or the actuator AKT in order to respectively assure a direct access of the measured data pick-up MDA to the measured data and of the actuator AKT to the system.

Figure 2 shows a differently constructed actuator AKT 2. Via the interface 201, this actuator AKT2 likewise receives a signal from the processor unit PRE that informs a computer R, which is part of the actuator AKT2, that a predetermined action is to be implemented. Further, an energy store BT is provided in the actuator AKT2, this energy store BT, controlled by the computer R, applying energy to the electrodes EL1 and EL2 in a suitable way. The computer R of the actuator AKT2 thereby controls the interface IF in order to preferably determine amplitude and frequency of the energy applied to the electrodes EL1 and EL2.

Figure 3 shows steps of the method implemented by the processor unit PRE.

A neural network NN is trained in a step 301. To this end, measured data of a suitable scope are prescribed in order -- following the training -- to be able to make a statement as to whether new measured data indicate an abnormality of the system. After the end of the training, an information flow (see [1] or [2]) is evaluated on the basis of current data in a step 302. An abnormality of the system can be indicated on the basis of this information flow before the occurrence of this abnormality. The abnormality is predicted in a step 303; an action that opposes an occurrence of the abnormality is implemented in a step 304. Subsequently, a branch is preferably made to the step 302.

Two applied examples follow, these illustrating the possibilities of a prediction of an abnormality.

Application 1: Electrocardiogram (ECG) Data

One application relates to the possible prediction of a fibrillating heart. The abnormality is comprised therein that the heart beats nearly chaotically.

ECG measured data are inventively employed in order to learn the dynamics of a heart of a patient (training phase of the neural network NN). It should thereby be noted that the dynamics of the heart vary greatly dependent, for example, on the time of day and the activity in which a person is engaged at the moment. Invariable quantities (prediction quantity) that significantly describe the dynamics of the heart of the person despite great variation should nonetheless be determined. A variation of the prediction quantity enables the prediction of an abnormality of the heart. A control mechanism that restores the normal heart rhythm is started upon recognition of the abnormality.

The prediction quantity represents an imaging of a sudden variation of the complexity of the dynamics, and the actuator is realized in the form of an electrode that delivers small electrical pulses to the heart.

Application 2: Electroencephalogram (EEG) Data

The brain, preferably the human brain, is another dynamic system. When it is assumed that EEG measured data represent brain activity, one task is to suitably interpret the signals and potentially link predetermined measures thereto. Thus, an epileptic attack is characterized by a synchronous firing of a group of neurons that are arranged centered around a mid-point. This synchronism reduces the complexity of the dynamics of the brain and is indicated by EEG measured data. In contrast thereto, the normal condition, i.e. the normally working brain, represents a condition of irregularly firing neurons.

The early recognition of an epileptic attack becomes possible by determining a continued simplification of the dynamics of the brain. The actuator for restoring the normal condition has the job of opposing this synchronism that is apparently responsible for the epileptic attack. This preferably occurs by applying a field, as explained in greater depth below.

We shall turn to the second applied example for avoiding an epileptic attack below for further-reaching comments.

The Dynamic Prediction Quantity

The idea is comprised in the expansion of the statistical approximation according to [2] for detecting a Markov character in which a given empirical time row is inherent. One objective is to separate a deterministic part form a stochastic part of a dynamic system in the surround of the statistical test theory in that the information flow of the system is analyzed. The statistical development of the dynamics is tested against a hierarchy of zero hypotheses that correspond to non-linear Markov processes with increasing order n. These processes are divided into a deterministic part and a stochastic part in the following way:

$$x_t = f(x_{t-1},\ldots,x_{t-n}) + u \qquad (1),$$

whereby u indicates an additive noise distributed according to Gauss with the variance σ^2, x_t indicates a measured datum at the time t and f(...) indicates a deterministic part.

The Markov process with the order n is defined by the conditioned probability densities thereof

$$p(x_t \mid x_{t-1}, \ldots, x_{t-n}) \propto \exp\left(-\frac{\left[x_t - f(x_{t-1}, \ldots, x_{t-n})\right]^2}{2\sigma^2}\right) \qquad (2).$$

The deterministic part is implemented by a neural network NN that is trained according to the maximum likelihood principle [4] applied to the probability densities according to Equation (2). The stochastic part u is described by noise distributed according to Gauss, whereby the variance σ^2 is referred to a defined, mean last [sic] quadratic error. In other words, the zero hypotheses contain not only the order of the Markov process but also an actual deterministic structure. When a chaotic condition is present, thus, the order of the accepted zero hypothesis is the EED (effective embedding dimension). This approach opens up a method for determining the EED, whereas temporary measured data are modelled parallel thereto.

This approach also allows a strict expansion of the concept of ED (embedding) when a chaotic condition prevails. The express determination of the deterministic part is a method for filtering the noise out of the time row.

The zero hypothesis is implemented with a method described in [2].

As known from [1] and [2], an information flow, i.e. a non-parametric criterion of a predictable development, is used as a discriminating statistic. A significance test is thus implemented for every point in time to be predicted, whereby the zero hypothesis (i.e. a given assumption that is to be checked) is only accepted when the significance test is met for all quantities of the point in time to be predicted.

Analysis of Human Epilepsy Attacks

As described above, one application of the invention is represented by the analysis of EEG measured data in order to prevent an epileptic attack. One goal is thereby to test whether a dynamic classification of the measured data for time windows of different size can be used as prediction quantities in order to predict an epileptic attack. In particular, two prediction quantities are recited:

a) The "reminder" of the underlying dynamics, i.e. the EED (see the above comments);

b) a non-parametric criterion for a predictability, defined by the integration of the information flow.

The approach presented here does not assume that the underlying dynamics are chaotic (even if they could be); rather, the emphasis lies on the time span preceding the epileptic attack in order to define a prediction quantity for the epileptic attack that is based on the dynamics of the system.

Control of the Epileptic Attack

An epileptic attack can be suppressed in that a constant electrical field is supplied to the regions that are affected by the epileptic attack (see [5]).

According to an assumption that the normal condition of the brain is marked by chaotic dynamics, an epileptic attack is expressed by a drastic simplification of the dynamics in the brain. The epileptic attack is countered in that the reduction of the dynamics, i.e. the synchronicity is, as described above, opposed in that a noise is supplied to the system, the brain in this case.

The delivery of this noise is preferably generated by applying an electrical field or a magnetic field in the immediate environment of (as close as possible to) the location of the action. Electrodes for generating an electrical field or coils for generating a magnetic field are preferably employed for this purpose. The synchronously firing neurons in the epileptic attack have their synchronicity disturbed by the electrical and/or magnetic field; a (seemingly) chaotic firing of the neurons is re-established in the brain, the epileptic attack has thus been averted.

It is thus fundamentally important that a suitable reaction is carried out in response to an abnormal behavior of a dynamic system, whereby the abnormal behavior is detected with a prediction quantity. Dependent of the field of employment, this reaction is comprised, for example, in generating a chaotic or in generating a regular field. This action, which is implemented by the actuator, is dependent on the respective field of employment. What the various versions of the method respectively have in common is a dynamic learning, whereby a significant abnormality is allocated to a prediction quantity and this prediction quantity enables a detection of an impending abnormality. It is thereby expedient to implement a suitable action with the actuator within a predetermined time interval preceding the occurrence of the abnormality (of the epileptic seizure or of the chaotically beating heart). The prediction quantity thus enables the recognition of an abnormality before this actually occurs.

Since the entire system changes over a longer time span in view of its dynamically normal property, an adaption of the originally learned dynamic system is expedient. It is important to define the prediction quantity in that the data significantly characterizing an abnormality are imaged from the entire dynamic system in the prediction quantity. A prediction of the abnormality can thus ensue even given a dynamic system subject to great fluctuations, for example a heart that is subjected to the greatest variety of stresses, whereby one of these stresses does not necessarily indicate an abnormality.

The following publications were cited in the framework of this document:

[1] G. Deco, C. Schittenkopf and B. Schürmann, "Determining the information flow of dynamical systems from continuous probability distributions", Phys. Rev. Lett. 78, pages 2345-2348, 1997.

[2] C. Schittenkopf and G. Deco, "testing non-linear Markovian hypotheses in dynamical systems", Physica D104, pages 61-74, 1997.

[3] J. Herz, A. Krogh, R. Palmer, "Introduction to the Theory of neural computation", Addison-Wesley, 1991.

[4] G. Deco, D. Obradovic, "An Information-Theoretic Approach to Neural Computing", Springer-Verlag, 1996, Chapter 7.2.

[5] B. Gluckmann, E. Neel, T. Netoff, W. Ditto, M. Spano, S. Schiff, "Electric field suppression of epiletiform activity in hippocampal slices", Journal of Neurophysiology 76, pages 4202-4205, 1996.

Patent Claims

1. Arrangement for predicting an abnormality of a dynamic system and for implementing an action opposing the abnormality,

a) whereby a measured data pick-up is provided that registers comparison measured data of the system and test measured data of the system,

b) comprising a processor unit that is configured such that the following steps can be implemented:

c) a neural network that describes the system is trained upon employment of the comparison measured data;

(2) a comparison information flow that describes a comparison dynamic of the system is determined upon employment of the trained neural network;

(3) a test information flow that describes a test dynamic of the system is determined upon employment of the test measured data;

(4) upon employment of the comparison information flow and of the test information flow, the abnormality is predicted as established when the comparison information flow differs significantly from the test information flow and the abnormality is predicted as not established when the comparison information flow does not significantly differ from the test information flow;

(5) when the abnormality of the system has been predicted as established, then the action is implemented;

c) whereby an actuator that implements the action is provided.

2. Arrangement according to claim 1, whereby the steps (2) and (5) of the processor unit form an endless loop.

3. Arrangement according to claim 1 or 2, whereby the abnormality is predicted as established when test information flow is significantly smaller than the comparison information flow.

4. Arrangement according to claim 3, whereby the action is comprised in exciting the system with a chaotic signal.

5. Arrangement according to claim 4, whereby the action is comprised in suppling noise to the system.

6. Arrangement according to claim 5, whereby the noise is supplied on the basis of a corresponding electrical field.

7. Arrangement according to claim 6, whereby the electrical field is supplied on the basis of at least one electrode.

8. Arrangement according claim 5, whereby the noise is supplied on the basis of a corresponding magnetic field.

9. Arrangement according to claim 8, whereby the magnetic field is supplied on the basis of at least one electrode.

10. Arrangement according to claim 1 or 2, whereby the abnormality is predicted as established when test information flow is significantly greater than the comparison information flow.

11. Arrangement according to claim 10, whereby the action is comprised in exciting the system with a regular signal.

12. Arrangement according to claim 11, whereby the regular signal is supplied on the basis of an electrical field.

13. Arrangement according to claim 11, whereby the electrical field is supplied on the basis of at least one electrode.

14. Arrangement according to claim 11, whereby the regular signal is supplied on the basis of a magnetic field.

15. Arrangement according to claim 14, whereby the magnetic field is supplied to the system on the basis of at least one electrode.

16. Method for predicting an abnormality of a dynamic system and for implementing an action opposing the abnormality, whereby

a) comparison measured data of the system and test measured data of the system are measured,

b) a neural network that describes the system is determined upon employment of the comparison measured data;

c) a comparison information flow that describes a comparison dynamic of the system is determined upon employment of the neural network;

d) a test information flow that describes a test dynamic of the system is determined upon employment of the test measured data;

e) upon employment of the comparison information flow and of the test information flow, the abnormality is predicted as established when the comparison information flow differs significantly from the test information flow and the abnormality is predicted as not established when the comparison information flow does not significantly differ from the test information flow;

f) when the abnormality of the system has been predicted as established, then the action is implemented.

17. Method for predicting an abnormality of a dynamic system, whereby

a) comparison measured data of the system and test measured data of the system are measured,

b) a comparison information flow that describes a comparison dynamic of the system is determined upon employment of the comparison measured data;

d) a test information flow that describes a test dynamic of the system is determined upon employment of the test measured data;

e) upon employment of the comparison information flow and of the test information flow, the abnormality is predicted as established when the comparison information flow differs significantly from the test information flow and the abnormality is predicted as not established when the comparison information flow does not significantly differ from the test information flow.

Abstract

Arrangement for Predicting an Abnormality of a System and for Implementing an Action Opposing the Abnormality

An arrangement is presented that enables a prediction of an abnormality and implements a suitable action opposing the abnormality. An information flow underlying a dynamic system is thereby interpreted and a prediction quantity that comprises the abnormality as characterizing quantity of the dynamic system is determined therefrom. A neural network is trained with measured data of the system. After the training, the abnormality can be indicated on the basis of the prediction quantity before it occurs and the occurrence can be opposed with suitable measures.

FIG 1

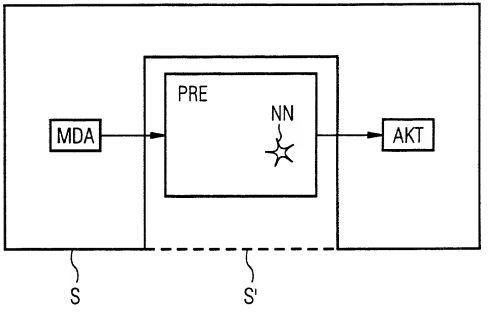


FIG 2

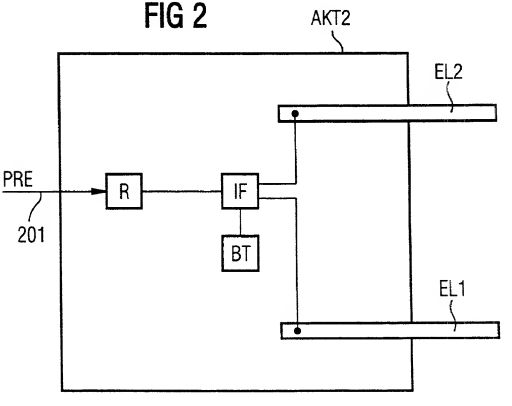
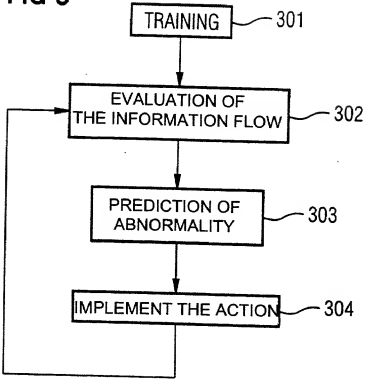


FIG 3


TRAINING
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Declaration and Power of Attorney For Patent Application
Erklärung Für Patentanmeldungen Mit Vollmacht
German Language Declaration

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I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Anordnung zur Vorhersage einer Abnormalität eines Systems und zur Durchführung einer der Abnormalität entgegenwirkenden Aktion

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Prior foreign appplications
Priorität beansprucht

			Priority Claimed	
19749373.4	Germany	7. November 1997	☒	☐
(Number) (Nummer)	(Country) (Land)	(Day Month Year Filed) (Tag Monat Jahr eingereicht)	Yes Ja	No Nein
			☐	☐
(Number) (Nummer)	(Country) (Land)	(Day Month Year Filed) (Tag Monat Jahr eingereicht)	Yes Ja	No Nein
			☐	☐
(Number) (Nummer)	(Country) (Land)	(Day Month Year Filed) (Tag Monat Jahr eingereicht)	Yes Ja	No Nein

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I hereby claim the benefit under Title 35 United States Code. §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §122, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occured between the filing date of the prior application and the national or PCT international filing date of this application

(Application Serial No.) (Anmeldeseriennummer)	(Filing Date) (Anmeldedatum)	(Status) (patentiert, anhängig, aufgegeben)	(Status) (patented, pending, abandoned)
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And I hereby appoint

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Staatsangehörigkeit: Italien	Citizenship
Postanschrift: Klarastr. 13 D-80636 München Bundesrepublik Deutschland	Post Office Address
Voller Name des zweiten Miterfinders (falls zutreffend):	**Full name of second joint inventor, if any:**
DUBÉ, Louis-J.	
Unterschrift des Erfinders — Datum: 9/11/1998	Second Inventor's signature — Date
Wohnsitz: Sillery, Prov. de Québec. G1T 2M4, Canada	Residence
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Postanschrift: 1556 av. du Parc Beauvoir Sillery, Prov. de Québec, G1T 2M4 Kanada	Post Office Address

(Bitte entsprechende Informationen und Unterschriften im Falle von dritten und weiteren Miterfindern angeben).

(Supply similar information and signature for third and subsequent joint inventors).